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The Increasing Need for the Representation of Decision Making and Human Behaviour in Simulations Used for Computer Assisted Exercises in NATO

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Summary

In computer assisted exercises aimed at staffs and commanders operating in NATO headquarters, simulation models are used by response cell personnel to represent the behaviour of the forces that they are commanding. Exercise directing staff and personnel managing other forces involved in the exercise interact with the simulations to complete the representation of the behaviour of the world that is relevant for the achievement of the exercise objectives. Hence the quality of the exercise depends heavily on the quality of the personnel that interact with the simulation environment. Their ability to understand and interpret the intentions of the exercising staff and to provide them with relevant information through their regular command and control information systems is critical to the success of an exercise. Due to the increasing number of different aspects of the real world and associated scenarios that need to be exercised, the range of activities represented in the simulation models and the breadth and depth of knowledge of the personnel who operate them must grow and adapt rapidly. However the time to develop new simulation models and to adapt existing ones to new requirements has not been reduced considerably in the last decade. The availability of highly qualified personnel to interact with simulations, represent subordinate commanders and staffs, intelligent opponents and interested third parties is limited in both numbers and time. So although considerable improvements have been made in the preparation of the simulation environments to meet exercise objectives, most computer assisted exercises suffer from poorly trained response cell and other forces personnel. Also the reduction in the size of forces, the greater effect and effectiveness of weapons and the importance of inflicted damage causes individual tactical decisions and actions to have a major impact on the battlefield and the exercise. Therefore, the ability to incorporate automated representations of autonomous planning and decision making and real time conduct of operations will be critical in overcoming these problems. Equally important will be the development of intelligent information presentation entities capable of interfacing with small numbers of simulation operators and with real world command and control information systems. It appears that progress in the representation of computer generated forces and human behaviour modelling may allow these capabilities to be developed. The ability to enable them to go beyond reproducing known behaviour according to established patterns and display some form of creative thinking and unanticipated behaviour will be essential in making them effective for any length of time.

1 Current Practice of CAX in NATO

"A computer assisted exercise (CAX) is a Command Post Exercise in which computer-based simulation models are used to place commanders, staffs and their command and control systems in an operationally realistic environment in order to perform decision-making, practice staff procedures and co-ordinate between headquarters." *(ACE CAX Planners Course*)

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A number of groups of persons complement the simulation environments in providing a realistic and challenging environment for the exercising staffs. They include:

(1) Response cells, which constitute the interface between the exercising staff and the simulation environment. They represent all subordinate units, perform the corresponding decision making process, interact with simulated entities and provide information feedback to the staffs. A growing number of automated interfaces between simulations and NATO command and control information systems enable response cells to provide data in the format that staffs are familiar with.

(2) A white cell, which represents other elements that provide information to the exercising, staff e.g. media or political leadership.

(3) One or many opposing or other forces cells which manage other active and simulated entities. They develop plans and execute them in order to meet the exercise objectives.

(4) A directing staff which interacts with all exercise components including the exercising staffs to monitor the progress of the exercise.

(5) An analysis team collects data during the preparation and conduct of the exercises to provide feedback on the achievement of the exercise aims and objectives.

Two distinct levels of decision making are the typical focus of computer assisted exercises in a NATO context:

(1) the operational level of decision making where the most important problem areas that require resolution center around the assessment of threat, the specification of the resources required to achieve the assigned objective within the assessed threat environment and the general allocation of joint and combined resources to specific tactical tasks. The time frame of events that is relevant to the decision making process at these levels is expressed in weeks and days rather than in minutes.

(2) the level of decision making that constitutes the transition between the operational and the highest level of tactical decision making. At this level, single service considerations start to become of overriding influence. They are still focused at the usage of large structured groups of persons and equipment and consider the environment at a macro-level. The time frame that this level of decision making considers is shorter than the previous level but is still expressed in days and hours rather than minutes.

The decision making process is a combination of qualitative assessments and quantitative aggregate data processing. The associated information generated by either the headquarters' subordinates or other sources is both structured and unstructured. Typically the higher the level of decision making, the smaller the quantity of structured information. Hence the greater need for response cells to understand the intent of the exercising staffs and their need for assessments rather than facts.

The simulations that are used to support CAXes in NATO have been selected based on their functionality and their level of granularity. Indeed, interaction with the simulations is typically carried out by the response cells and other forces cells at the level of the simulated entity. Reporting from the simulations is also typically at the simulated entity level. Due to the nature of NATO exercises, the simulated entities have always been relatively aggregated elements e.g. army battalions, flights of aircraft or naval task groups.

2 Changing Requirements

The change in NATO's security environment that has taken place since 1989 and the new missions that NATO has been called on to perform, have had a considerable impact on the types of simulation environments required to support the growing variety of exercise objectives.

Specifically due to the types of operations that are currently undertaken by NATO in a peace support context, there is a growing need to track the activities of individual entities as well as structured groups of entities. Indeed, the size of the forces involved are relatively limited. In these operations, the decisions that are made by individual entities and at every level of organization are carrying an increasing degree of importance and therefore of interest to senior decision makers. The growing capability of small forces and the effectiveness of single weapon systems contribute further to this trend. Both the expected and unexpected effects of weapon employment need to be represented in exercise simulation environments to provide a representative information flow to the exercising staffs and commanders.

Another marked change in requirements is the collaboration with civilian organizations either governmental or private in nature. Their activities need to be represented as well as their interaction with local populations.

All the above elements require simulation environments for CAXes to include a wider variety of entities with behaviours that have not been studied in this field in the past. In addition the interactions between the traditionally simulated entities in CAX-driving simulations and these new entities are not well structured and understood. Overall, there is a tendency to demand a growing level of granularity in order to understand the behaviour of the entire set of entities.

An aspect that complicates the development of simulation environments that meet these changing requirements is the increased usage in NATO of direct interfaces between the simulations and the command and control information systems (CCIS) used by the exercising staffs. These interfaces include such capabilities as automated report generation in a format that can be processed automatically by a CCIS, the provision of air and maritime track data but also the processing of structured order sets produced by the exercising staffs. The usage of these interfaces limits the ability of the exercise control organisation to influence the course of the simulated events in any intrusive manner. Hence control needs to be executed with greater insight. Better fidelity of entity behaviours is expected due to this increased visibility. The ability to explain the occurrence of certain unexpected and apparently illogical events is critical in achieving confidence in the simulation environment used to support a CAX. Conversely, exercising staffs need to take sufficient care in the development of plans, which are transmitted as structured tasks to automated entities. Usually the simulated entities have limited ability to validate the tasking and may therefore execute errors in a perfect manner rather than provide some form of feedback requesting confirmation of the tasking.

3 Solutions and Constraints

In order to respond to the change in requirements described in the previous section, a number of different approaches have been proposed and applied in the NATO context. Most notably, a resurgence of purely scripted exercises or largely scripted CAXes has been observed. The traditional problem, associated with scripted exercises, of providing consistent responses over time to the exercising staffs and commanders with the required level of detail has been re-discovered. The complexity of managing the interactions between a wide variety of entities and of conveying the perceptions of opposing or non-aligned entities cannot be resolved in this manner. Hence exercise effectiveness has been limited and this approach can only be applied to exercises that focus on a very limited set of objectives and that aim to exercise a limited group of people. The facets associated with a combined joint operation in a multi-national and multi-party environment cannot be simulated using this approach.

Other approaches are based on simulation technology. They can be classed in the following categories:

(1) the introduction of greater granularity in existing and proven aggregate simulations.

(2) the search for simulations that have a greater degree of granularity whilst maintaining a wide spectrum of functions.

(3) the proposed connection between aggregate and detailed simulations or between complementary detailed simulations.

(4) the development of new simulations.

All these approaches focus on achieving the required detailed level of granularity in the simulated entities. They also assume that interaction with the simulation(s) for order input and information retrieval, must take place at this level of detail. Therefore, they require the utilisation of large amounts of augmentation personnel to bridge the gap between simulation and exercising staffs. However the number of available augmentees is decreasing. Due to the rise in numbers of exercises to meet the larger set of operational tasks, they are also in greater demand. Consistent reductions in exercise budgets further limit the deployment of augmentation personnel. Even in the case that numbers of people and funds were available, it has been noted that there is great variance in the skill level of the augmentation personnel and that this variance detracts significantly from the achievement of exercise objectives.

Another element that needs to be taken into account, is the considerable increase in exercise preparation time lines due to the more complex simulation data base development process. Indeed more creative and lateral thinking is needed when applying existing simulations and more development effort is required when building data bases for several simulations and ensuring their consistency. The uncertainty concerning the resulting behaviour of the simulations does not contribute to a smooth and consistent process.

From a technical perspective, it must also be noted that the limited resources available to develop and evolve simulation environments prevent the proliferation of new simulations based on new requirements.

Therefore we must conclude that without a complementary approach to reduce the complexity and detail of the interaction with the simulation environments that are used in CAXes and a focus on the exercise preparation process also, these approaches cannot be applied in cost-effective manner.

4 The Need for Human Behaviour Representation

It becomes apparent from the previous section that the problem of simulating with greater detail while interacting at an aggregate level needs to be resolved in a structural manner. Therefore, it is necessary to augment the description of simulated entities with more complex behavioural representations in particular in the areas of decision making and information processing.

In addition, there is a requirement for a more formal meta-model of the simulated entities to enable their proper configuration and their associated entities during the exercise preparation process. In the context of this paper, we will limit the discussion to the entities that are being simulated.

The issue of the validation of simulation results also requires an explicit representation of the behavioural process of the simulated entities. Not only the actions of entities but their rationale needs to be reproducible and available for inspection. Hence the following characteristics of an entity need to be described explicitly:

(1) the capability to maintain a perception of the state of the world and how it pursues this objective,

(2) the manner with which it assesses potential changes in the state of the world and its ability to apply this process,

(3) the ability to receive and interpret taskings,

(4) the manner with which taskings are interpreted,

(5) the ability to communicate with other entities that are capable of providing useful information and that in turn may need data.

Obviously when instantiated in the simulation execution some level of variance needs to be introduced to ensure a non-stereotypical and reasonably unpredictable behaviour. These characteristics can be used to describe individual and groups of humans.

In addition the process that entities apply to adapt and change their behaviour to achieve certain goals, needs to be defined. Goals could be expressed in terms of intrinsic goals e.g. survival, or externally driven goals e.g. tasking by interacting personnel or other entities. Changes in behaviour could be temporary or become permanent according to some explicitly described process.

Due to the considerable change in requirements described in the previous section, the spectrum of human behaviour that needs to be represented is very broad. It includes:

(1) military staffs and decision makers representing the subordinates of the exercising staffs and commanders as well as the crews operating vehicles or pilots flying aircraft and all the intermediate levels of decision making and information processing

(2) Non-Governmental and Private Volunteer Organisations as groups and as individuals

(3) civilian population groups and key individuals

(4) other military force structures described in a similar manner as the own forces

(5) national agencies either political and military, capable of providing additional information or guidance

(6) commercial and private groups or companies that can provide resources e.g. transportation assets or relevant information e.g. news, terrain or weather data.

The diverse nature of the entities listed above and the many factors that can influence their behaviour, indicates that the task of modelling them will not be an easy one. However it is essential to start introducing corresponding behavioural models in our simulation environments to provide a sufficiently complete representation of the environment in which senior military decision makers and their staffs will be placed in most future operations. The introduction of automated behaviour is critical in providing a consistent quality of training and exercising and in making it affordable.

In addition to modelling the ability of these entities to gather data, to assess situations, to evaluate courses of action, to decide on a preferred path, to communicate it and to execute it, close attention must be given to the fact that these behaviours will change over time. The model development cycle must therefore be shorter than the actual behavioural adaptation cycle. Ensuring an adaptive design to the modelling of human behaviour will be key to its continued success and utility in an exercising environment designed for high-level staff and decision makers.

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Overview

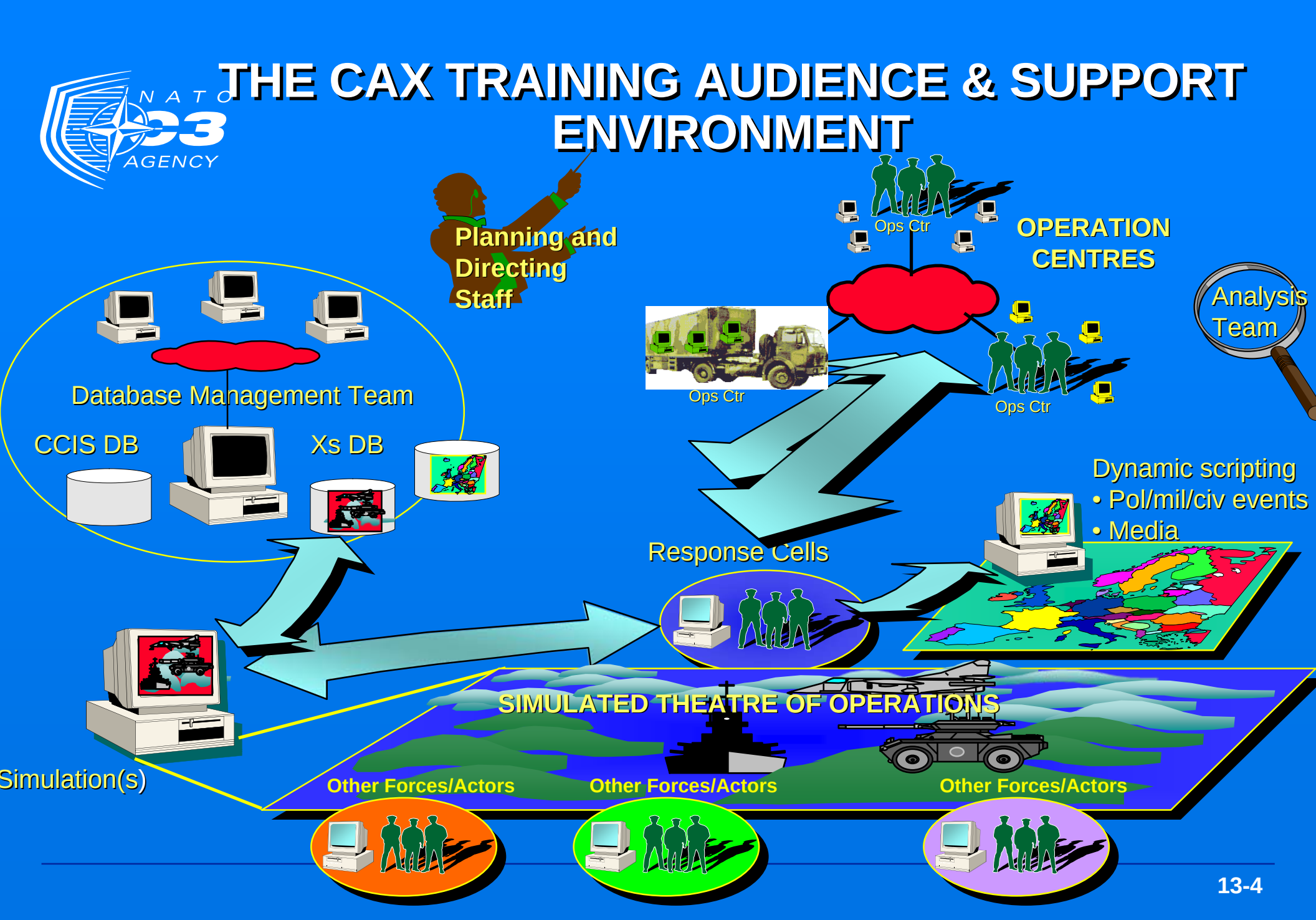
- Definition of CAX
- CAX Components
- NATO Exercise Characteristics
- Recent New Requirements
- Recent Solutions
- Why Human Behaviour Representation
- Critical Requirements of HBR

Definition of CAX

A Command Post Exercise in which computer-based simulation models are used to place commanders, staffs and their command and control systems in an operationally realistic environment in order to perform decision-making, practice staff procedures and co-ordinate between headquarters.

Source*: *ACE CAX Planners Course

THE CAX TRAINING AUDIENCE & SUPPORT ENVIRONMENT



NATO EXERCISE REQUIREMENTS

- Orientated at two levels primarily

- First level: Operational level
  - Main Tasks:
    - –Threat assessment
    - –Allocation of resources to tactical decision makers
  - Focus on joint combined usage of forces: Corps, air force composition, maritime task forces
  - Time frame: weeks, days

NATO EXERCISE REQUIREMENTS

- **Second level: Operational/Tactical level**
  - **Main tasks:**
    - **More detailed assessments**
    - **More emphasis on single service considerations in joint context**
  - **Focus on divisions, air force asset allocation to tasks, maritime task groups**
  - **Time frame: days**

RECENT NEW REQUIREMENTS (1)

- **Peace Support Operations**
  - **Humanitarian aid**
  - **Disaster Relief**
  - **Search and Rescue**
  - **Peace Keeping**
  - **Peace Enforcement**
- **Implemented through Combined Joint Task Force concept**
  - **Tailored headquarters**
  - **Formed by personnel from various HQs**

RECENT NEW REQUIREMENTS (2)

- **Level of granularity**
  - Division, Brigade,Battalion and below
  - Single aircraft or helicopter
  - Single ship
  - Tailored small force

  - Actions of individual entities and their associated effect
  - Effect of single resource or weapon employment

  - Time frame: days, hours, minutes

RECENT NEW REQUIREMENTS (3)

- **New entities**
  - **Para-military organisations**
  - **Non-military:**
    - **Non-Governmental and International Organisations**
    - **Local population**
    - **Commercial entities e.g. ships, airlines**
    - **Media**
    - **Specific persons e.g. leadership**

RECENT NEW REQUIREMENTS (4)

- **Modelling and simulation implication**
  - **Need to represent aggregate and detailed entities behaviour, decision making and information exchange**
  - **Need to control and explain entity behaviour**
  - **Level of effort and expertise of Response cells much greater**

RECENT NEW REQUIREMENTS (5)

Direct interface with command and control systems

- **Allow tailored staff to exercise with working environment**
- **Behaviour of simulated world increasingly obvious to exercising staff allowing less intervention by exercise control to “fix” problems**

RECENT SOLUTIONS (1)

- **Resurgence of scripted exercises**
  - Large scripted events lists prepared and executed, dynamic scripting during execution
  - Traditional problems re-occur: maintain consistent joint perception, time and space consistency, logistics implications of actions, provision of detailed intelligence data
  - Only successful for small exercise audience

RECENT SOLUTIONS (2)

- **Simulation-based solutions**
  - **Add more detail to proven aggregate simulations:stretching basic modelling concepts**
  - **Use more detailed simulations: very few joint simulations available**
  - **Combine aggregate and detailed simulations through model-interoperability protocols**
  - **Combine complementary detailed simulations through model-interoperability protocols**

RECENT SOLUTIONS (3)

- Common problems to current solutions
  - Uncertainty of effectiveness of solutions
  - Size and expertise of exercise control structure
  - Increased preparation time

WHY HUMAN BEHAVIOUR REPRESENTATION ?

- Explicit representation of behavioural models for all active entities will reduce the level of interaction of exercise control staff with simulation environments
  - Reduction in scripting staff
  - Reduction in controller intervention
- Aggregate entities capable of de-aggregating
  - Groups in sub-groups
  - Groups into individuals
  - Groups into combinations of groups and individuals
- Behaviour can be traced and validation of training environment performed

WHY HUMAN BEHAVIOUR REPRESENTATION ?

- **Critical in representing breadth of required entities and their simultaneous interactions**
  - **Consistent representation with commensurate level of information**
  - **Cannot be performed manually due to complexity and associated manpower for management**
- **Critical in achieving more effective configuration and setup of exercise environment**
  - **Ability to select from existing sets rather than re-invent**
  - **Ability to forecast exercise flow**

CRITICAL REQUIREMENTS OF HBR

- Variance in behaviour of similar entities when instantiated
  - Avoid stereotypical, easily predictable behaviours
- Explicit representation of behavioural adaptation process either temporary or permanent
  - Analysis of own actions and ability to learn
  - Representation of memory of solutions to previous problem situations
- Ability to develop new HBRs within requirements development time frame

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